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Sub partu monitoring of the fetus by cardiotocography and fetal blood analysis

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1 Introduction

When using cardiotocography (CTG) to monitor the fetus during labor, the obstetrician is confronted time and again with the question as to whether or not the CTG alone is sufficient to adequately determine the status of the fetus, or whether a fetal blood analysis (FBA) should be run as a double-check on the CTG findings.

Up to the present, there are no standard, generally accepted guidelines for this problem. There is no general consensus on this topic in German language textbooks on obstetrics, and there are divergent opinions as to following the procedure whereby the decision to run a FBA is made subsequent to the assessment from the CTG results [2, 5, 9]. Only recently were new FIGO guidelines for the use of fetal monitoring published [8].

A work by GÖSCHEN [2] is concerned with the value of the CTG evaluation according to HAMMACHER and that of the FBA, and he shows that there is no particularly good correlation between the CTG score and the pH value. The HAMMACHER score is nevertheless still recommended for the sub partu CTG evaluation; the FBA should be used additionally in order to avoid unnecessary, overhasty decisions for operative deliveries. The classical CTG signs of fetal distress – late deceleration, bradycardia, e.g. – were not often associated with acidosis in GÖSCHEN's work. This, however, stands in contradiction to other works which have reported such a connection, based on qualitative CTG evaluations [6].

It is generally accepted that a normal CTG picture indicates a normal acid-base status in the fetus, while an abnormal CTG either indicates that the fetus is in danger or is an expression of a physiological variation which is related to a pathological heart rate pattern.

We analyzed results from our own patients to investigate the relationship between various CTG patterns and FBA values. To make these results comparable with those from other studies, the HAMMACHER score was used for the CTG evaluation.

Curriculum vitae

SUSANNE BAER, *M. D., was born in 1953. She studied medicine at the University of Zurich, where she received her degree in 1981, and where she has been a member of the medical staff in the Department of Obstetrics and Gynecology since 1983.*

2 Materials and methods

For this retrospective study, 200 women with singleton pregnancies were chosen; all were at the University Hospital in Zurich and all were monitored by CTG and, when indicated by the CTG findings, by micro blood sampling. Of the 200 patients, seven (3.5%) were under 20 years of age, 50 (25%) were between 20 and 24 years, 60 (30%)

were between 25 and 29 years, 58 (29%) were between 30 and 34 years, 23 (11.5%) were between 35 and 39, and two (1%) were over 40 years of age. There were 138 (69%) who were primipara, 44 (22%) para II, 13 (6.5%) para III, three (1.5%) para IV and two (1%) para V.

Gestational age at birth varied from just under 28 gestational weeks (GW) to over 42 GW, with the majority (56%) between the 40th and 42nd GW. Most were born spontaneously (59%), but there was also a considerable number of deliveries which were either assisted (by forceps or vacuum extraction) or Cesarean sections. The details are outlined below:

Gestational Age at Delivery	Nr.	Nr. Spont. Births	Nr. Obstetric Interventions		
			C. S.	Forceps	Vacuum Ext.
under 28 GW	1	1	–	–	–
32–35 GW	6	5	–	–	1
36–39 GW	69	39	13	8	9
40–42 GW	111	66	14	20	11
after 42 GW	13	7	4	2	–

Running backwards in 30-minute intervals from the time of delivery, the CTG was evaluated by HAMMACHER's method [4] and the HAMMACHER scores compared with the FBA results for the corresponding time intervals. Per patient, up to five MBAs were made. In all, there were 306 parallel evaluations of CTG and FBA. In evaluating the results, the influence of sedatives and opiates which had been administered was taken into account.

The blood sample was obtained by a capillary tube with a central heparin thread after the usual incision had been made. The analysis of the blood gas acid-base composition was performed by a Micro Autocal pH Blood Gas Analyzer 613 from Instrumentation Laboratory, USA.

Immediately after delivery, the cord was clamped and blood was taken from the umbilical artery; the sample was transported in a glass capillary tube and analysed in the (same) blood gas analyzer.

The adaptation of each newborn during the first 10 minutes of life is routinely checked in our clinic using the APGAR scores. The data obtained were arranged and analyzed with the help of a special program developed in our clinic for the representation and evaluation of clinical data [7].

The validity of the CTG score with respect to the range in which the pH value obtained from the micro blood sample was expected to lie was statistically tested and evaluated. Sensitivity, specificity, predictive value for positive and negative test results and efficiency were calculated [1]. To correct the positive predictive value, an incidence of a low micro-blood sample pH value of 5% was assumed.

3 Results

In 86% of the 306 FBA evaluations which were clinically indicated, the retrospective analysis according to HAMMACHER showed a CTG score which was, with three or more points, at least suspect (see table I). In 27% of the measurements there was a prepathologic CTG (score 5–7), and in only 1% a pathologic CTG (score 8–12). The use of opiates in the group with normal and suspect findings was, with 35%, higher than either in the group with prepathologic CTG patterns (28%) or in the group with pathologic CTG patterns (just one of the four patients).

Table I. Distribution of the Hammacher Scores

Hammacher Score		Number	%
0– 2	normal	40	13
3– 4	suspect	178	58
5– 7	prepathologic	84	27
8–12	pathologic	4	1
		306	100

Most of the FBA pH values were in the normal range – i.e., 85% with a pH equal to or above 7.25. Eleven percent had reduced pH values between 7.25 and 7.20, and only 3% were found to be in the pre-acidotic or acidotic range under 7.20 (table II). A comparison of the CTG scores and the FBA pH values shows that in no case with a normal CTG score (0–2) was there a pH value under 7.20, whereas 3% with a suspect CTG score (3–4) and 6% with a prepathologic score (5–7) had pH values below 7.20. None of the four patients with a pathologic CTG score in our study had a pH value below 7.20 (table III).

Table II. Distribution of FBA-pH values

FBA-pH	Number	%
< 7.20	10	3
≥ 7.20 < 7.25	34	11
≥ 7.25 < 7.30	105	34
≥ 7.30	157	51
	306	100

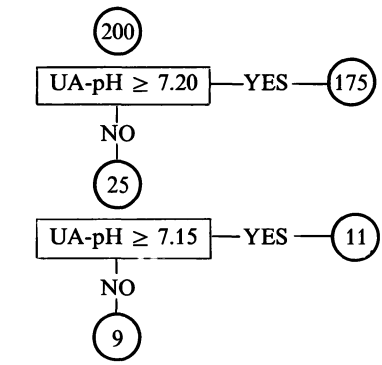
Table III. Comparative distribution of Hammacher Scores and FBA-pH values

FBA-pH / Hammacher Score	≥ 7.20	< 7.20	n
Normal	40	0	40
Suspect	173	5	178
Prepathologic	79	5	84
Pathologic	4	0	4

Of the 10 FBA pH values under 7.20, five occurred with a suspect CTG score of 3–4 and the other five with a prepathologic score of 5–7 (table III). If a pH value under 7.20 was determined, as was the case in six patients, obstetric intervention was chosen, the type dependent upon the stage of labor: three times a Cesarean section, three times an operatively assisted vaginal delivery. None of these patients had received opiates.

Of the 200 infants born in the course of the study, 25 (12.5%) had an umbilical arterial pH value under 7.20, and in nine of these (4.5%) the value was less than 7.15. None had a value lower than 7.04, however, and all newborns had a 10-minute APGAR score of at least seven. In only one of the acidotic infants was there no "warning signal" – i.e. no abnormal score – from the CTG in the time just preceding birth; one other had a "suspect" score of three, two had a score of four, and for the other five acidotic infants, the acidotic tendency was indicated within 30 minutes prior to birth by a rise in the HAMMACHER score to five or more points (table IV). Studying the statistical results (table V), we see that during delivery the CTG (as assessed by HAMMACHER's scores) in relation to the FBA pH value is very sensitive (1.0) – a reduced pH value is always associated with

Table IV. Low umbilical arterial pH values and Hammacher Scores



Hammacher Score	
0–2	1
3–4	3
5–7	5

Table V. Efficacy of the Hammacher Score

Hammacher Score / FBA-pH	< 7.20	≥ 7.20
≥ 3	10	256
≤ 2	0	40
n	10	296
Sensitivity	1.0	
Specificity	0.135	
Predictive Value ⊕		
uncorrected	0.037	
corrected	0.057	
Predictive Value ⊖	1.0	
Efficiency Quota	0.16	

an elevated CTG score – yet not very specific (0.135), since higher CTG scores were usually associated with a normal pH value. This becomes especially clear in the predictive value of the CTG for low pH (0.037 uncorrected; 0.057 corrected). On the other hand, the high sensitivity is expressed by the predictive value of 1.0 for a normal pH value. Taken together, there is an efficiency quota of only 0.16 (16%).

4 Discussion

The still open question as to whether or not it is necessary to run FBAs with the current standard of technology available with cardiotocography can not be answered easily. GÖSCHEN ran a study in 1984 [2] which showed no particularly good correlation between CTG scores and FBA pH values, yet he came to the conclusion that by not performing a FBA, one risks either performing an unnecessary operative intervention or not detecting a fetal acidosis.

HAMMACHER is of another opinion, feeling that the FBA itself poses an additional risk to the fetus, and without producing the desired clinical result [3]. The figures in our study, however, seem to support GÖSCHEN's thesis.

Since the CTG is very sensitive but not specific in relation to fetal pH values, it has to be validated by a FBA. This means that while a normal CTG can nearly always be a safe and sure sign that the fetus is not acidotic, a suspect or prepathologic CTG finding during the birth process defines a risk group in which only about 4% of the fetuses will have a pH value less than 7.20. The FBA is thus an additional test to help determine the validity of the highly sensitive yet relatively unspecific CTG in these individual cases.

5 Conclusions

In summary, it should again be pointed out that there is only a small incidence of low FBA pH values, and that while the CTG does indeed not miss any of the cases with acidosis or pre-acidosis, it is so unspecific that the "success rate" of identification is scarcely 4%. When there is suspicion of fetal compromise based on CTG findings, an additional test such as the FBA should be used to either confirm or refute these suspicions.

Abstract

A retrospective study to determine how well cardiotocogram (CTG) and micro blood analysis (FBA) results correspond to each other was made on 200 deliveries which had been monitored sub partu by these techniques.
FBA was performed 306 times. CTG results were analysed according to Hammacher's method and the scores compared with the FBA results. In 40 cases with a normal HAMMACHER score, a normal FBA-pH value, as expected, was also found. In a total of 266 observations with a CTG score greater than two, there were simultaneously 10 times (scarcely 4%) found when there was a FBA value under 7.20. Of the 200 infants involved, 25 had a cord arterial pH value under 7.20. Ten minutes after birth, all of these infants were doing fine, with an APGAR score of at least seven. Statistically, sub partu CTG analysis according to HAMMACHER's method is highly sensitive, yet not very specific, when compared to the corresponding FBA-pH value.

Keywords: Cardiotocogram, cord-pH, fetal blood analysis, sensitivity, specificity.

Zusammenfassung

Subpartuale Überwachung des Feten durch Kardiotokogramm und Fetalblutuntersuchung
Anhand von 200 Geburten am Universitätsspital Zürich, die mit Kardiotokogramm (CTG) und Fetalblutanalyse (FBA) überwacht wurden, wurde retrospektiv analysiert, inwieweit CTG und FBA korrespondieren. Insgesamt konnten 306 mal CTG und FBA konkordant ausgewertet werden. Ab Geburt wurden die CTG rückwärts in 30 Minuten-Intervallen nach HAMMACHER ausgewertet und die gefundenen Scores den FBA-Werten zugeordnet. Berücksichtigt wurde die Gabe von zentral sedierenden Medikamenten. Das Alter, die Parität sowie das Gestationsalter und der Geburtsmodus wurden festgehalten. Bei 266 (86%) ausgewerteten klinisch indizierten FBA-Untersuchungen lag nach HAMMACHER ein zumindest suspektes CTG mit einem Score von 3 und mehr Punkten vor. Dabei konnte bei 84 (27%) ein präpathologischer (Score 5–7) und nur bei vier (1%) ein pathologischer Score (8–12) gefunden werden. Der Opiatgebrauch war in der Gruppe mit normalen und suspekten Befunden

mit 35% wenig höher als in den Gruppen mit präpathologischen (28%) und pathologischen Mustern (eins von vier).
Bei den FBA-Werten zeigte sich, daß die meisten im Normbereich lagen, nämlich 262 (86%) mit einem pH > 7,25. Bei 34 (11%) waren die Werte im reduzierten Bereich und nur 10 (3%) lagen im präazidotischen bzw. azidotischen Bereich pH < 7,20.
Erwartungsgemäß zeigte sich, daß in keinem der Fälle mit normalem HAMMACHER-Score ein pH-Wert unter 7,20 gefunden wurde, während es bei suspekten und präpathologischen Scores 3% (5 von 178) bzw. 6% (5 von 84) waren. In keinem der 4 Fälle mit pathologischem Score wurde ein pH-Wert unter 7,20 gefunden. Von insgesamt 10 FBA-pH-Werten unter 7,20 traten fünf bei einem suspekten und die anderen fünf bei einem präpathologischen Score auf. Bei den sechs Fällen mit einem FBA-pH-Wert unter 7,20 bei der letzten FBA, wurden drei vaginal-operativ und drei per Sektio caesarea entbunden. In keinem Fall waren Opiate verabreicht worden.
Von den 200 Kindern wurden 25 (12%) mit einem arteriellen Nabelschnur-pH-Wert < 7,20 geboren, bei allen war jedoch der 10 Minuten APGAR-Wert mindestens sieben. Bei sieben der azidotischen Kinder kündigte sich die Azidose innerhalb 30 Minuten vor Geburt durch eine Erhöhung des HAMMACHER-Scores auf 4 und mehr Punkte an, während nur bei einem Kind in dieser Zeit ein normales CTG vorlag.
Teststatistisch ausgewertet zeigte sich, daß das CTG unter der Geburt, nach HAMMACHER beurteilt, bezüglich des korrespondierenden FBA-pH-Wertes mit 1,0 zwar hochsensitiv ist, daß es jedoch mit 0,135 als wenig spezifisch angesehen werden muß. Das heißt, das CTG erfaßt zwar mit einem mindestens suspekten HAMMACHER-Score von drei und mehr sämtliche Feten mit einem FBA-pH-Wert unter 7,20, die Zahl der miterfaßten Feten mit normalen pH-Werten ist jedoch recht groß. Zusammenfassend schließt ein normales CTG unter Geburt fast mit Sicherheit eine fetale Acidose aus. Ein suspekter oder pathologischer Befund definiert jedoch eine Risikogruppe, bei der in 3% ein pH-Wert unter 7,20 gefunden werden kann. Somit stellt die FBA eine Untersuchung dar, die das hochsensitive, jedoch relativ unspezifische intrapartuale CTG im Einzelfall ergänzen und absichern sollte.

Schlüsselwörter: Fetalblutanalyse, Kardiotokogramm, Nabelschnur-pH, Sensitivität, Spezifität.

Résumé

Surveillance du fœtus au cours du travail par cardiotocographie et micro-analyses sanguines
On a réalisé à l'hôpital universitaire de Zürich une étude rétrospective, afin de déterminer la concordance des résultats du cardiotocogramme (CTG) et des micro-analyses sanguines (FBA). Cette étude a porté sur 200 accouchements qui ont été surveillés tout au long du travail par ces techniques.
Au total, on a effectué 306 évaluations parallèles du CTG et des MBA. Le CTG a été analysé par la méthode d'HAMMACHER, en réalisant des périodes de trente minutes précédant l'accouchement. Les scores d'HAMMACHER ont été comparés aux résultats des FBA correspondant à la même période. On a retenu pour l'interprétation des résultats, l'influence des sédatifs qui ont été administrés. On a noté l'âge de la mère, sa parité et l'âge gestationnel à la naissance, ainsi que le mode d'accouchement.
Sur les 306 FBA réalisées, 266 soit 87% étaient indiquées cliniquement. L'analyse rétrospective effectuée selon HAMMACHER a montré un score CTG supérieur ou égal à 3 points, c'est-à-dire pour le moins suspect. Pour 84 FBA, (27%), le CTG était prépathologique (score 5–7) et c'est seulement dans 4 FBA, (1%) que le CTG était pathologique (score 8–12). L'utilisation des opiacés dans le groupe ayant des résultats normaux ou suspects a été plus grande avec 35% que dans le groupe avec les tracés CTG prépathologiques (28%) ou dans le groupe avec les tracés pathologiques (une patiente sur quatre seulement).
L'observation des valeurs du pH montre que la majorité se situe dans la normalité c'est-à-dire que 262, (85%) étaient supérieures ou égales à 7,25; 34 (11%) étaient comprises entre 7,25 et 7,20 et seulement 10 (3%) étaient dans la zone préacidotique ou acidotique, inférieure à 7,20.
La comparaison des scores CTG et des valeurs du pH par FBA montre que, comme on pouvait s'y attendre lorsque le score CTG est normal il n'y a pas de pH inférieur à 7,20. Parmi les 10 pH par FBA inférieurs à 7,20, 5 accompagnaient un score CTG suspect et les cinq autres, un score prépathologique. Parmi les 6 observations de pH inférieur à 7,20, 3 ont abouti à une césarienne, et 3 à une aide à l'expulsion par voie basse. Aucune de ces patientes n'a reçu d'opiacés.
Sur les 200 enfants nés au cours de cette étude, 25 (12%) ont eu un pH sanguin de l'artère ombilicale inférieur à 7,20, toutefois tous auraient des scores d'APGAR supérieurs ou égaux à 7. Ce n'est que chez un seul enfant acidotique qu'il n'y a pas eu de « signe d'alarme », c'est-à-dire, un score anormal sur le CTG juste avant la naissance; chez sept enfants en acidose, la tendance acidotique s'est manifestée au cours des trente minutes précédant la naissance par une élévation du score d'HAMMACHER supérieure ou égale à 4 points.
En étudiant les résultats statistiques, nous avons trouvé qu'au cours de l'accouchement, le CTG (étudié à l'aide du score d'HAMMACHER) mis en relation avec le pH par FBA est très sensible (1,0). Un pH abaissé s'accompagne toujours d'un score CTG élevé. Mais n'est pas très

spécifique (0,135). C'est ainsi que bien qu'un score d'HAMMACHER supérieur ou égal à 3 (c'est-à-dire au moins dans la zone suspecte) soit trouvé chez tous les fœtus avec un pH par FBA inférieur à 7,20, le nombre de fœtus avec un pH normal et avec un score CTG au moins suspect est assez important.
En résumé, on peut établir qu'un tracé CTG normal au cours du travail est un signe tout à fait sûr d'absence d'acidose fœtale. Un score CTG suspect ou (pré) pathologique définit un groupe à risque au sein duquel 3% des enfants peuvent avoir un pH inférieur à 7,20. Quand on suspecte une souffrance fœtale en se fondant sur les données du CTG hautement sensible, mais relativement peu spécifique, on devrait faire appel à un test additionnel tel que les FBA pour confirmer ou infirmer cette suspicion.

Mots-clés: Cardiotocogramme, micro-analyses sanguines, pH du sang du cordon, sensibilité, spécificité.

References

[1] GALEN RS: In: SONNENWIRTH AC, L JARETT (eds): GRADWOHL's Clinical Laboratory Methods and Diagnosis. (8th ed) St Louis, Mosby 1980
[2] GÖSCHEN K, T GRUNER, E SALING: Stellenwert des HAMMACHER-Scores und der Fetalblutanalyse bei der subpartualen Überwachung des Kindes. Z Geburtsh Perinat 44 (1984) 608–610
[3] HAMMACHER K: Zum Thema: FBA und oder CTG. Geburts Frauenheilk 44 (1984) 608–610
[4] HAMMACHER K, R BRUNDELRE, P DEGRANDI, R RICHTER: Kardiotokographischer Nachweis einer fetalen Gefährdung mit einem CTG-Score. Gynaek Rdsch 14 (1974) Suppl I 61
[5] HUCH A: Die Überbewertung der Kardiotokographie und die negativen klinischen Auswirkungen. In: DUDENHAUSEN JW, E SALING (eds): Perinatale Medizin, Bd 10 (11. Deutscher Kongreß für Perinatale Medizin) Thieme, Stuttgart, 1984
[6] KÖPPEL R, I BENZ: Senkung der Sectiorate durch Ausschluß cardiotokographisch vermuteter Acidosen mittels fetaler Blutgasanalysen (MBU). Geburtsh Frauenheilk 44 (1984) 573–575
[7] MÜLLER R: Zum Problem der Erfassung und Auswertung von klinischen Daten. Dissertation. Zürich 1986
[8] ROOTH G, A HUCH, R HUCH: FIGO News Guidelines for the use of fetal monitoring. In: Int J Gynaecol Obstet 25 (1987) 159–167
[9] SALING E: Die Überbewertung der Kardiotokographie und die negativen klinischen Auswirkungen. In: DUDENHAUSEN JW, E SALING (eds): Perinatale Medizin, Bd 10 (11. Deutscher Kongreß für Perinatale Medizin) Thieme, Stuttgart, 1984

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